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Musa borneensis Becc. (Musaceae) and its Intraspecific Taxa in Borneo

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Borneo, being part of the centre of banana origin, is home to a large number of wild bananas. *Musa borneensis* was one of the first *Musa* species from the island that was described by the Italian botanist Dr. Odoardo Beccari in the nineteenth century. In the twentieth century, the Japanese Prof. Mitsuru Hotta described a closely related variety of *M. borneensis,* and named it *M. flavida.* However, each botanist studied different areas of the island and could not observe the close relation to the other varieties. The *M. borneensis* group from Borneo has been studied extensively in the field during 2001 – 2004 in Malaysia (Sarawak and Sabah) and Brunei by the authors. Keys and a table of differentiating characteristics of each variety are provided. Six distinct *M. borneensis* varieties have been identified: *alutacea, borneensis, flavida, lutea, phoenicea,* and *sarawakensis.* Four of these varieties are described and illustrated as new varieties. We propose re-classifying *M. flavida* as a variety rather than as a species, as its degree of differentiation is well within the variations of the other varieties described.

Key words: Borneo, *Musa borneensis, Musa borneensis* var. *alutacea, Musa borneensis* var. *borneensis, Musa borneensis* var. *flavida, Musa borneensis* var. *lutea, Musa borneesis* var. *phoenicea, Musa borneensis* var. *sarawakensis, Musaceae,* wild banana.

Borneo has a large number of endemic wild banana species, and their number may now total 20, though only 15 species have been previously described (Häkkinen 2004). *Musa borneensis* is very similar in size and appearance to a common cultivated banana. Leaves have curved-patent petiole, sheath margins glabrous, auriculate, embracing and heavily wrinkled (Fig. 1. var. *phoenica*). Inflorescence is large, unilateral and pendent (Fig. 2. var. *sarawakensis*). Male flowers are uniseriate, 5-8 per bract, white, greenish at the top; bracts from yellow to rose-wine-coloured, reflected, rolled back at the tip. *Musa borneensis* consistently differs, however, from cultivated bananas with regard to the arrangement and shape of male flowers, seeded fruits and heavily wrinkled auricles. It could be also easily distinguished from the other Bornean *Callimusa* species from its distinct obpyriform seeds, which are unique in the whole *Callimusa* section (Häkkinen 2004).

With the discovery of the newly described varieties of *Musa campestris* (Häkkinen 2002, 2003) and *M. borneensis* varieties described in this paper, the intraspecific taxa of those species are increased considerably. The present paper is largely based on field observations made by the first author during the expeditions in 2001, 2002, and 2004 to Sarawak, Sabah and Brunei and the second author's observations made in Sarawak during 2004.

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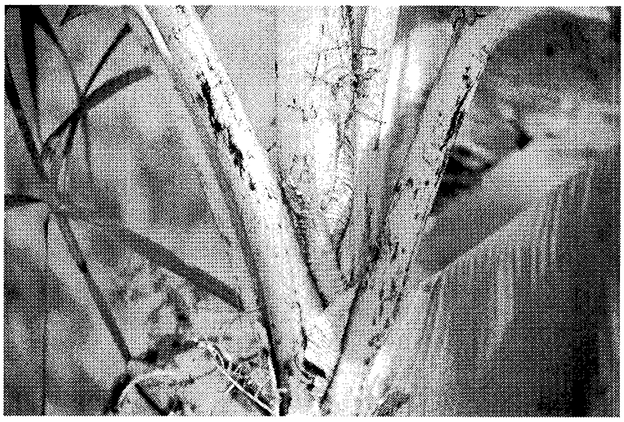

FIG. 1. Heavily wrinkled auricles of var. *phoenica.*

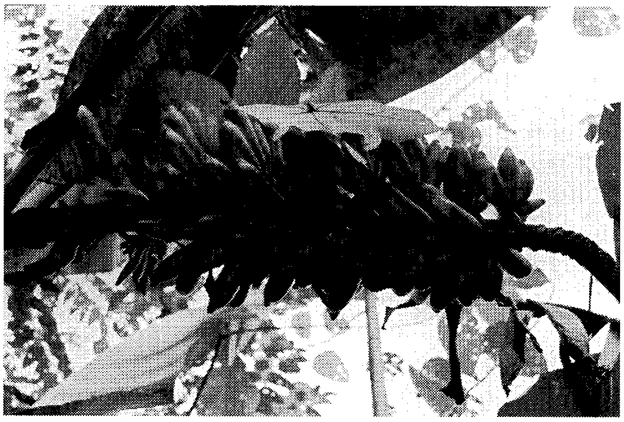

FIG. 2. Large horizontal fruit bunch of var. *sarawakensis.*

It became very clear to the authors during the study that huge variations of wild bananas had developed in small gaps in dense forest, where genetic divergence and specification took place. When man came into the picture with land clearing forests were opened up and bananas became more abundant, exposing the many different genetic populations that had already been developed.

History

The Italian botanist Odoardo Beccari was the first to describe four wild bananas from Borneo in his classic book "Nelle Forestre di Borneo" (Beccari 1902). He described and named four species: *Musa borneensis, M. campestris, M. hirta* and *M. microcarpa.* Beccari made his studies in Sarawak during the period of 1865-68.

After Beccari's description, Prof. E. E. Cheesman wrote in Kew Bulletin 5(2), 1950 as follows: "We received seeds at I. C. T. A. in 1931 from the Director of Agriculture, Sarawak, with the label "Pisang kra", from which we succeeded in raising a single plant which is somewhat delicate under our (Trinidad) conditions but has been kept alive as a clone and flowered several times. This plant fits Beccari's commendably detailed description and figures so closely that I have no hesitation in identifying it as *Musa borneensis*". "On this characteristic seed shape the species is referable to my section *Callimusa*, and it has the chromosome number of that section (n=10) (count recorded in J. Genetics 30: 16 (1935) as "*Musa* sp. undet. from Sarawak", where it is erroneously classified under *Rhodochlamys*)." Cheesman continued: "I saw numerous plants of this species along the Simanggang Road, 26 miles from Kuching, in 1948. (Cheesman & Larter 1935, Cheesman 1947, 1950).

Prof. N. W. Simmonds (who never visited Borneo) gave the following comments in Kew Bulletin Vol. 14, 1960: "Cheesman, during a visit to Borneo in 1948, recognized what he took to be a new *Callimusa* at Tawau, Br. N. Borneo. This plant is represented in two collections of R. Foster (I. C. T. A. Intr. 348, Jan. 1951; and Intr. 497, Aug. 1955 from the Kinanbatangan River). The vernacular name is Pisang wongkod and the notes and photographs indicate a large plant with light yellow sap, large dense horizontal bunches and yellow male bracts" He continued: "The seeds are similar to those of *Musa borneensis*, to which the plant is evidently related. No fewer than seven other introductions received at various times from different parts of Borneo all agree in seed characteristics, and it is evident that one or both species is or are widely distributed in the island. Only one of these introductions proved to be viable and the plant turned out to be *M. borneensis* [(Intr. 278, Pisang

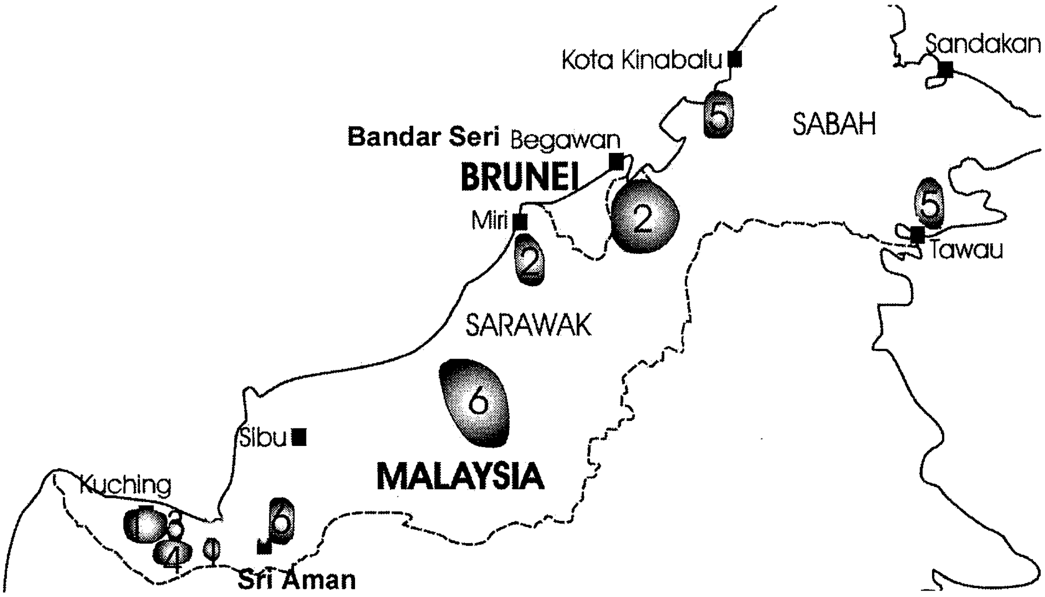

FIG. 3. Distribution map of *Musa borneensis* varieties: 1.var. *borneensis*. 2. var. *flavida*. 3. var. *alutacea*. 4. var. *phoenicea*. 5. var. *lutea*. 6. var. *sarawakensis*. Data is based upon field-bservations, not on specimens.

awai, from southeast Borneo) (Simmonds 1960)].

Hotta in Journ. Jap. Bot. 42: 344-352, 1967 wrote in his description for *Musa flavida*: "In 1959 Simmonds stated on a plant of the Sect. *Callimusa* from Borneo, that this is "a large plant with yellow sap, large dense horizontal bunches and yellow male bracts. We have, unfortunately, been unable to raise plants at the I. C. T .A". The present new species seems to be the same with this Simmonds' plant as shown by the large size of plant and yellowish male bracts. Fruit of our specimen is not yet well developed (this plant is non parthenocarpic), but I found a few uniseriate flowers on each bract, tridentate compound tepal of male flower, and boat-shaped free tepal with acute apex. By those characters, this species is deemed as an ally of *M. borneensis*" (Hotta 1967). *Musa borneensis* var. *lutea* was collected by Hotta. In sched.: *M. flavida* M. Hotta var. *sabahensis* M. Hotta on the following specimens: *S. Kokawa & M. Hotta 818, 2301, 2659*, and *M. Hotta 6117*. Although the labels connote a new variety, Hotta never provided a description of for the variety. It became clear during our studies in the same areas that the collection numbers 818, 2301 and 2659 are the same as our described variety *M. borneensis* var. *lutea* and the collection number 6117 is the same as our described variety *M. borneensis* var. *flavida*.

Cranbrook & Edwards' book "A tropical Rainforest – The nature of biodiversity in Borneo at Belalong, Brunei" has the following notable text on page 153: "*Musa borneensis,* a large species up to 7 m high, which appears mostly, if not totally, in the cream to yellow-bracted form (*M. "flavida"*), a colour variant of a widespread Borneo species that elsewhere has purplish or reddish bracts" (Cranbrook & Edwards 1994). Also the colour photo, which is shown in the book, confirms that it is var. *flavida.* The first author has also seen and studied the *var. flavida* in Brunei Temburong area and as well as Limbang, which is encompassed by West and East Brunei and agrees with the book's description.

Materials and Methods

Bananas are difficult collect as adequate herbarium samples, and representation in herbaria remains

Field key identification of *Musa borneensis* to variety level

1a. Plant 3.5 meter or below 2
1b. Plant more than 3.5 meter 3
  2a. Pseudostem colour purple-brown, sap milky, leaf base symmetric, male bud ovoid and red-purple, peduncle slightly hairy .... var. *borneensis*
  2b. Pseudostem colour red-purple, sap watery red-purple, leaf base asymmetric, male bud rounded and pink-purple, peduncle hairless .... var. *phoenica*
    3a. Pseudostem light green to medium-green, leaf base pointed on both sides, male bud yellow 4
    3b. Pseudostem purple-brown, sparse black-purple blotches at petiole base, leaf base rounded on both sides, male bud pink-purple .... var. *sarawakensis*
      4a. Male bud bract revolute before falling 5
      4b. Male bud bract not revolute before falling .... var. *alutacea*
        5a. 26 hands, 5-6 fruits per hand .... var. *flavida*
        5b. 36 hands, 4-8 fruits per hand .... var. *lutea*

poor. Photographs and accurate field notes convey more taxonomic information than dried herbarium material. For this reason this study is mainly comprised of morphological observations based on living plants in the field. It was conducted in Sarawak, Sabah and Brunei. The species was described by completing the entire INIBAP *Musa* Descriptor List (IPGRI-INIBAP/CIRAD 1996). The descriptive terms here also follow the tradition of banana taxonomy as used by Simmonds (Simmonds 1962, 1966). Relevant parts of the specimens were deposited as a holotype / isotype / specimen at the herbaria of the Department of Forestry, Sarawak, (SAR), the Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah (BORH), the Herbarium of Universiti Malaysia Sarawak (HUMS) or the Sarawak Biodiversity Centre (SBC). O. Beccari's original description, plate and drawing of *M. borneensis* provided the basic data for this study (Beccari 1902). In addition following herbaria also were studied: BM, E, K, KEP, P and SING for possible specimens of *M. borneensis.* However, the only specimen was found at K. Also KYO has provided 21 colour plates of their *Musa* specimens housed at their herbarium.

Suckers and a living specimen of *var. phoenica* and var. *sarawakenis* were delivered for propagation to the Sarawak Agricultural Research Centre, Semengoh. However, the first author's research permit to limited the number of *Musa* specimens that could be collected, to two herbarium species and one living shoot per species / variety. The complete descriptor list is available at the University of Helsinki, Finland, as well as at the aforementioned centres.

1. Musa borneensis Becc. var. **borneensis**, Figs. 3, 4A-E.

Musa borneensis Becc. Nelle foreste di Borneo, page 622, fig. 76. 1902.

Typus: MALAYSIA. Abita Sarawak a Marop. *P. B. n.* 3356. (FI, not seen).

Specimen examined and described here: MALAYSIA. Sarawak. Bau district, alt. 43 m., 01° 22.539' N, 110° 08.828' E, September 18, 2002, *M. Häkkinen 8019*, (SBC).

Plant slender, suckering freely, close to parent plant, up to 9 suckers, and of the height of the parent. Mature pseudostem up to 3.5 m high, sheaths purple brown, underlying colour cream with pink purple blotches, shiny, sap milky. **Petiole** up to 90 cm long, petiole canal open with erect margins, petiole bases winged and not clasping the pseudostem, and heavily corrugated auricles with sparse red purple blotches. **Leaf** habit erect up to 360 cm long, 75 cm wide, oblong, slightly narrowed towards the apex, roundly truncate at the tip, colour of upper surface green and shiny, lower surface medium green, and leaf bases symmetric and one side rounded, one pointed, midrib dorsally light green, ventrally yellow, with very corrugated lamina. **Inflorescence** first horizontal then pendulous, peduncle 50 cm long, 5 cm in diameter, slightly hairy and green-yellow in colour, sterile bract 1,

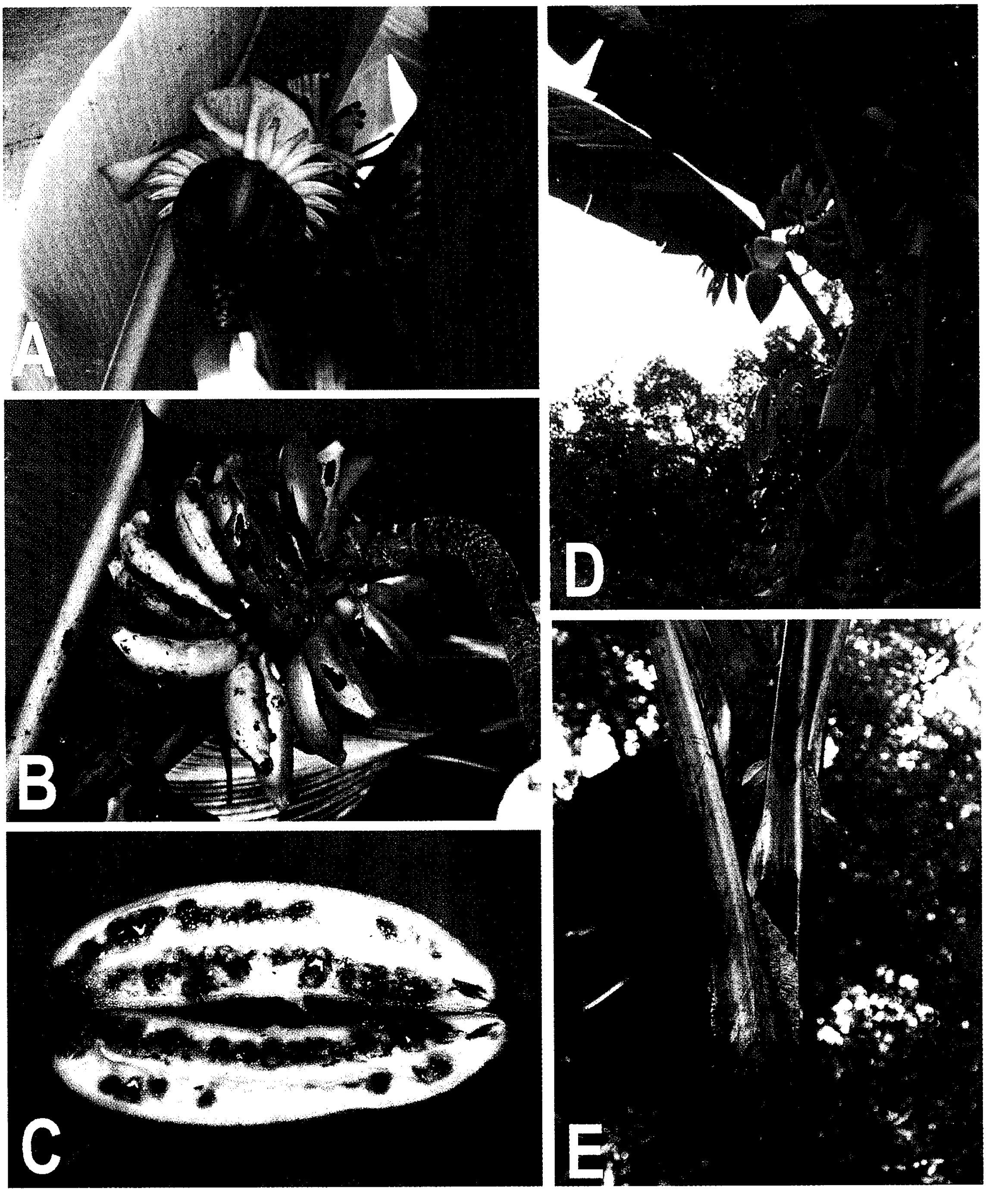

FIG. 4. *Musa borneensis* Becc. var. *borneensis*. A: Male bud. B: Fruit bunch. C: Cut fruit. D: Inflorescence. E: Heavily corrugated petiole auricles.

with foliage lamina, 80 cm long, 26 cm wide at base broadened, outer colour red-purple, inner yellow to purple, deciduous at the opening of the first female flowers. **Female flowers** on basal 20 nodes, each bearing on average 6 uniseriate female flowers, ovary 9 cm long, light green, arrangements of ovules in two rows per loculus, compound tepal 6 cm long, with two prominent thickened keels hyaline margins, white yellow in colour, the lobes green, free tepal 5 cm long, oval, boat shaped, 5 cm long, translucent white tinted with yellow, the style 4.5 cm long, cream stigma 0.6 cm in diameter. **Male bud** ovoid, 14.5 cm long, 12.5 cm wide, red-purple in colour, lifting two or more at a time, not revolute before falling. **Male flowers** on average 5 per bract in one row, compound tepal 4 cm long, cream in the upper part and yellow at the base, ribbed at the dorsal angles, with 5-toothed apex, outer lobes ovate, cuspidate, inner three lobes rotundate, the central one larger than the laterals, free tepal 2.5 cm long, translucent white, oblong, rotundate, simple folding under apex, fertile stamens 5, filaments 1.1 cm long, cream, anthers 1.3 cm long, white, anthers and style exserted, stigma tinted with purple, ovary arched, 1cm long, pale yellow, without pigmentation. **Fruit** bunch compact, with 20 hands and 5-8 fruits per hand on average, uniseriate, fingers inflexed to stand almost parallel to stalk, individual fruit 14 cm long, slightly curved, pronounced ridged, pedicel 2.7cm long, totally fused, apical part blunt-tipped shaped with truncate apex, immature fruit peel light green, becoming yellow at maturity, pulp white becoming cream and soft at maturity, astringed in taste. **Seeds** obpyriform, tuberculate, roughish in the upper half, 4-5 mm in diameter, 6-7 mm in height, 120-130 seeds per fruit. Chromosome number 2n = 20.

Distribution: Kuching, Bau and Samarahan.

Vernacular name: Pisang Kera (Iban, Malay); Enkadan (Iban), Kadan (Iban); Pisang hutan (Malay); Bikodon (Bidayuh, Bau).

Additional herbarium specimen examined: Bogor *4367* (K), MALAYSIA. Sarawak, near Bukit Begunan: 45 m. alt., 01° 05.716 N, 111° 23.287 E, September 25, 2002, *M. Häkkinen 8028* (SBC), Kota Samarahan (UNIMAS new campus): 27 m alt., August 19, 2004, *K. Meekiomg MK 1005* (HUMS).

Additional living material observed: MALAYSIA. Sarawak, Bau, 151 m alt., 01° 20,648 N, 110° 10.822 E, September 18, 2002, *M. Häkkinen, et. al.*, 43 m alt., 01° 16,155 N, 110° 20.322 E, September 19, 2002, *M. Häkkinen, et. al.*, 65 m alt., 01° 21,254 N, 110° 19,244 E, November 14, 2002, *M. Häkkinen, et. al.*

2. Musa borneensis Becc. var. **flavida** (Hotta) Häkkinen & Meekiong, **stat. nov.,** Figs. 3, 5A-E.

Musa flavida M. Hotta Journ. Jap. Bot. 42: 348, fig.1 J-M. Pl. VII. 1. 1967.

Typus: BRUNEI. Temburong: along Sungai Lacquan, a branch of Sungai Batu Apoi, alt. ca. 50 m, January 31, 1964, *M. Hotta 13876*, (KYO, three plates).

Specimen examined and described here: MALAYSIA. Sarawak, near Beluru, alt 91 m, 03° 59.627' N, 113° 57.653' E, October 25, 2002, *M. Häkkinen 8020*, (SBC).

Plant tall, robust, suckering freely, close to parent plant, up to 3 suckers, and of the height of the parent. Mature pseudostem up to 6 m high, sheaths medium green, underlying colour yellow with sparse purple blotches, waxy, sap milky. **Petiole** up to 90 cm long, petiole canal wide, erect margins, petiole bases winged and not clasping the pseudostem and heavily corrugated auricles with sparse blue blotches. **Leaf** habit erect up to 500 cm long, 90 cm wide, oblong, slightly narrowed towards the apex, roundly truncate at the tip, colour of upper surface medium green and dull, lower surface light green and dull with large purple-brown blotches, leaf bases asymmetric and both sides pointed, midrib dorsally light green to yellow, ventrally yellow with large purple-brown blotches, with very corrugated lamina. **Inflorescence** horizontal, peduncle 55 cm long 7 cm in diameter, hairless and medium green with sparse blotches, sterile bract 1, with foliage lamina, deciduous at the opening of the first basal flowers, relicts from unpollinated fruits. **Female flowers** on basal 26 nodes, each bearing on average 5 uniseriate female flowers, ovary 9 cm long, light green, arrangements of ovules in two rows per loculus, compound tepal 7 cm long, with two prominent thickened keels hyaline margins, watery-green in colour, the lobes green, free tepal, oval, boat shaped, 5 cm long, waterygreen, the style 4.5 cm long with globose cream stigma 1 cm long, 0.6 cm in diameter. **Male bud** ovoid, 18 cm long, 14 cm wide, bracts imbricate, apex obtuse with green tips, dorsally yellow shiny without discoloured stripes, ventrally pale yellow, with very little wax, lifting two or more bracts at a time and revolute before falling. **Male flowers** on average 5 per bract in one row, compound tepal 7.5 cm long, apex green and pale yellow in colour, ribbed at the dorsal angles, apex developed with 3 lobes, outer lobes acute with short dorsal appendages, the central lobe acute, free tepal

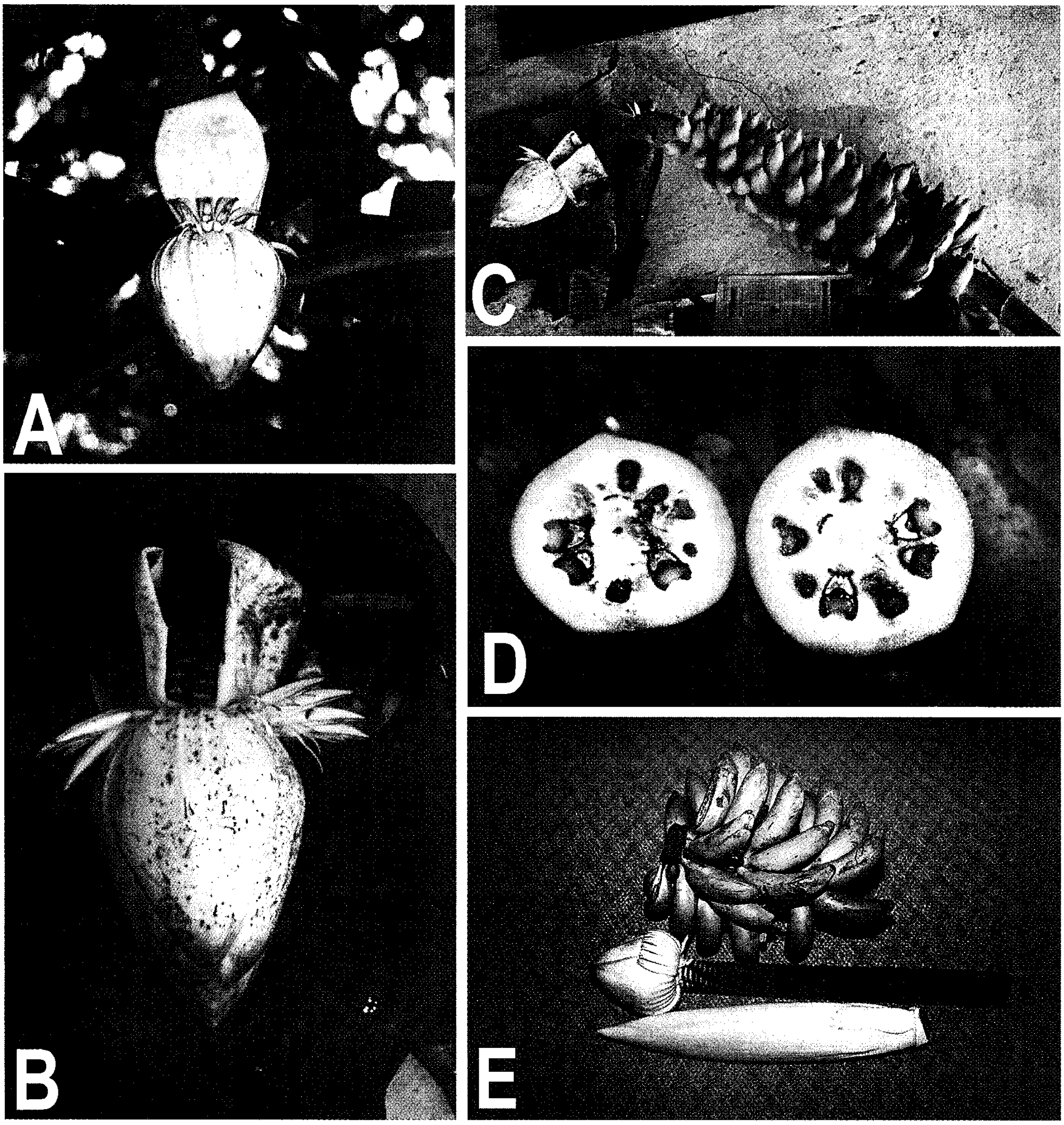

FIG. 5. *Musa borneensis* Becc. var. *flavida* Häkkinen & Meekiong, stat. nov. A-B: Male bud. C: Inflorescence / bunch. D: Fruit cut off. E: Bunch, male and female buds.

5.6 cm long, translucent white, lanceolate, with obtuse apex, simple folding under apex, style 3.5 cm, cream, fertile stamens 5, filament 1.4 cm long, cream, anther 2.1 cm long, white, anthers and style exserted, stigma tinted with purple, ovary arched, 1cm long, pale yellow, without pigmentation. **Fruit** bunch truncated cone shaped, compact, with 26 hands and 5-6 fruits per hand, uniseriate, parallel to stalk, individual fruit 14 cm long, curved (sharp curve) in shape, without any floral relicts on the fruit apex, pedicel 2.3 cm long, 1 cm wide, partially fused, apical part blunt-tipped shaped with truncate apex, immature fruit peel light green, becoming yellow at maturity, pulp white becoming cream and soft at maturity, astringed in taste. **Seeds** obpyriform, tuberculate, roughish in the upper half, 4-5 mm in diameter, 6-7 mm in height, 80-90 seeds per fruit. Chromosome number 2n = 20.

Distribution: Miri, Limbang and Lawas in Malaysia. Temburong area in Brunei.

Vernacular names: Pisang angkadan, Pisang gergasi.

Additional herbarium specimen examined: MALAYSIA. Sarawak, 4th Division, Sng. Bok, a branch of Tinjar River, near Long Taru, alt. 50-100 m, March 11, 1969, *M. Hotta 6117* (KYO), Limbang, 42 m alt., 04° 32.667 N, 115° 05.931 E, October 4, 2002, *M. Häkkinen 8018,* (SBC).

Additional living material observed: MALAYSIA. Sarawak, Limbang, 58 m. alt., 04° 35.254 N, 115° 15.122 E, October 4, 2002, *M. Häkkinen et. al.*, BRUNEI. Temburong, October 9, 2002, *M. Häkkinen et. al.*, MALAYSIA, Sarawak, Miri, near Long Lama, 49 m alt., 04° 11.361 N, 114° 02.170 E, October 25, 2002, *M. Häkkinen et. al.*, 92 m alt., 03° 59.627 N, 113° 57.653 E, May 12, 2004, *M. Häkkinen et. al.*,

3. Musa borneensis Becc. var. **alutacea** Häkkinen & Meekiong, **var. nov.,** Figs. 3, 6a-q.

A *M. borneensi* Becc. var. typica principali trunco pauce altiore, succo rubropurpureo, stigmate eburneo, infructescentia cum tantum 8 strictarum manibus baccarum, seminibus 80-100 in quaque bacca, pulpa cremea usque ad flava praecipue differt.

Typus: MALAYSIA. Sarawak. Samarahan, UNIMAS new campus site, on road side, alt. 33m, 01° 28.12' N, 110° 26.43' E, August 18, 2004. *K. Meekiong 1004* (holo SAR, iso HUMS).

Plant tall robust, suckering freely, close to parent plant, up to 9 suckers, position vertical. Mature pseudostem up to 4.5 m high, sheaths light green to yellow, underlying colour light green with pink-purple blotches, devoid of wax, sap red-purple. **Petiole** up to 120 cm long, petiole canal open with straight erect margins, petiole bases winged and clasping the pseudostem with heavily corrugated auricles and extensive black purple pigmentations. Fig. 6a. **Leaf** habit erect, lamina up to 450 cm long, 95 cm wide, oblong, slightly narrowed towards the apex, roundly truncate at the tip, colour of upper surface green and shiny, lower surface light green and dull, leaf bases asymmetric and both sides pointed, midrib dorsally light green, ventrally yellow, with very corrugated lamina. Fig. 6c. **Inflorescence** first horizontal then pendulous, peduncle 65 cm long, 5 cm in diameter, hairy and light green to yellow in colour, with pink-purple lines, sterile bract 1, with foliage lamina, deciduous at the opening of the first basal flowers. Fig. 6b. **Female flowers** on basal 8 nodes, each bearing 6-8 uniseriate flowers, ovary 4.2 cm long, cream, arrangements of ovules in two rows per loculus, compound tepal 3.6 cm long, with two prominent thickened keels hyaline margins, cream yellow in colour and light green at the tip, free tepal, boat shaped, 3 cm long, apex developed with triangular shaped, translucent white, style 3 cm long with globose cream stigma. Figs. 6g-h. **Male bud** intermediate (rounded to ovoid), 14 cm long, 12 cm wide, bracts imbricate, apex obtuse with green tips, dorsally leathery yellow, ventrally yellow, no visible sign of wax, deflexed but not rolled, deciduous. Fig. 6d. **Male flowers** on average 6 per bract in one row, compound tepal 4 cm long, the upper part light green in colour, and cream to orange at the base, ribbed at the dorsal angles, apex developed with two lobes, free tepal 2.5 cm long, translucent white, oval shape with triangular apex, simple folding under apex, fertile stamens 5, filament 1 cm long, white, anther 1.4 cm, pink purple, style 2.4 cm, white, anthers and style at the same level, stigma cream, ovary arched, 1.2 cm long, cream without pigmentation. Figs. 6i-p. **Fruit** bunch compact, with 8 hands and 6-8 fruits per hand, first hand 8 fruits and the last hand 6 fruits, uniseriate, parallel to stalk, individual fruit 8 cm long, straight in shape, without any floral relicts on the fruit apex, pedicel 1 cm, partially fused, apical part blunt-tipped shaped with truncate apex, immature fruit peel light green, becoming yellow at maturity, pulp cream becoming yellow and soft at maturity. **Seeds** obpyriform, tuberculate, roughish in the upper half, 4-5 mm in diameter, 6-7 mm in height, 80-100 seeds per fruit. Fig 6 q. Chromosome number 2n = 20.

Distribution: Samarahan only.

Vernacular names: Engkadan, pisang kadan

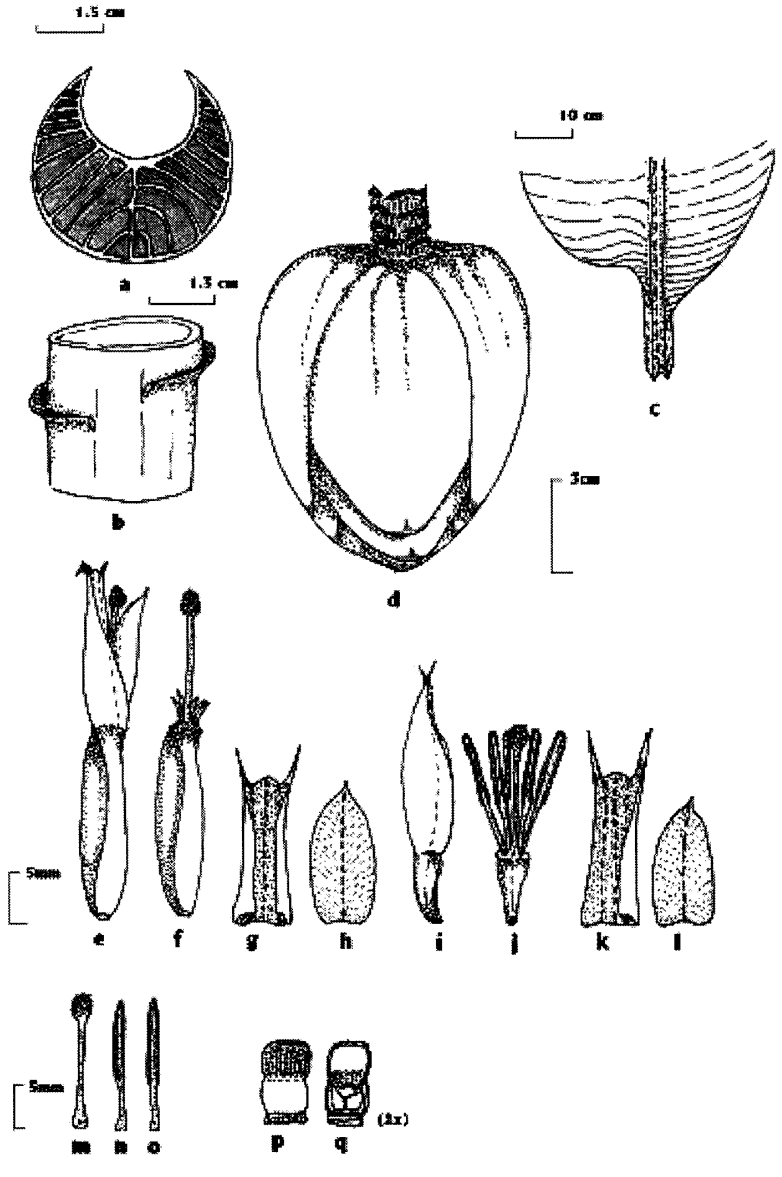

FIG. 6. *Musa borneensis* Becc. var. *alutacea* Häkkinen & Meekiong, var. nov. a: Cross-section of petiole. b: Peduncle. c: Leaf base. d: Male bud. e, f: Female flower. g: Compound tepal of female flower. h: Free tepal of female flower. i, j: Male flower. k: Compound tepal of male flower. l: Free tepal of male flower. m: Style with stigma. n, o: Staminodes with anther. p, q: Seed.

(Iban).

4. *Musa borneensis* Becc. var. **lutea** Häkkinen & Meekiong, **var. nov.,** Figs. 3, 7a-j, 8.

A *M. borneensi* Becc. var. typica principali trunco pauce altiore, surculis usque ad 2 tantum, succo flavo pallido, inflorescentia obliqua cum pedunculo atropurpureo, stigmate eburneo, infructescentia truncato-conica cum 36 manibus baccarum praecipue differt.

Typus: MALAYSIA. Sabah. Crocker range. Alt. 28 m, 05° 32.611' N, 115° 59.123' E, May 17, 2004. *M. Häkkinen & J. Gisil 14,* (holo BORH, iso BORH).

Plant tall, robust, suckering freely, close to parent plant, up to 2 suckers, position vertical. Mature pseudostem up to 4.5 m high, sheaths medium green, underlying colour yellow with red-purple blotches, devoid of wax, sap light yellow. **Petiole** up

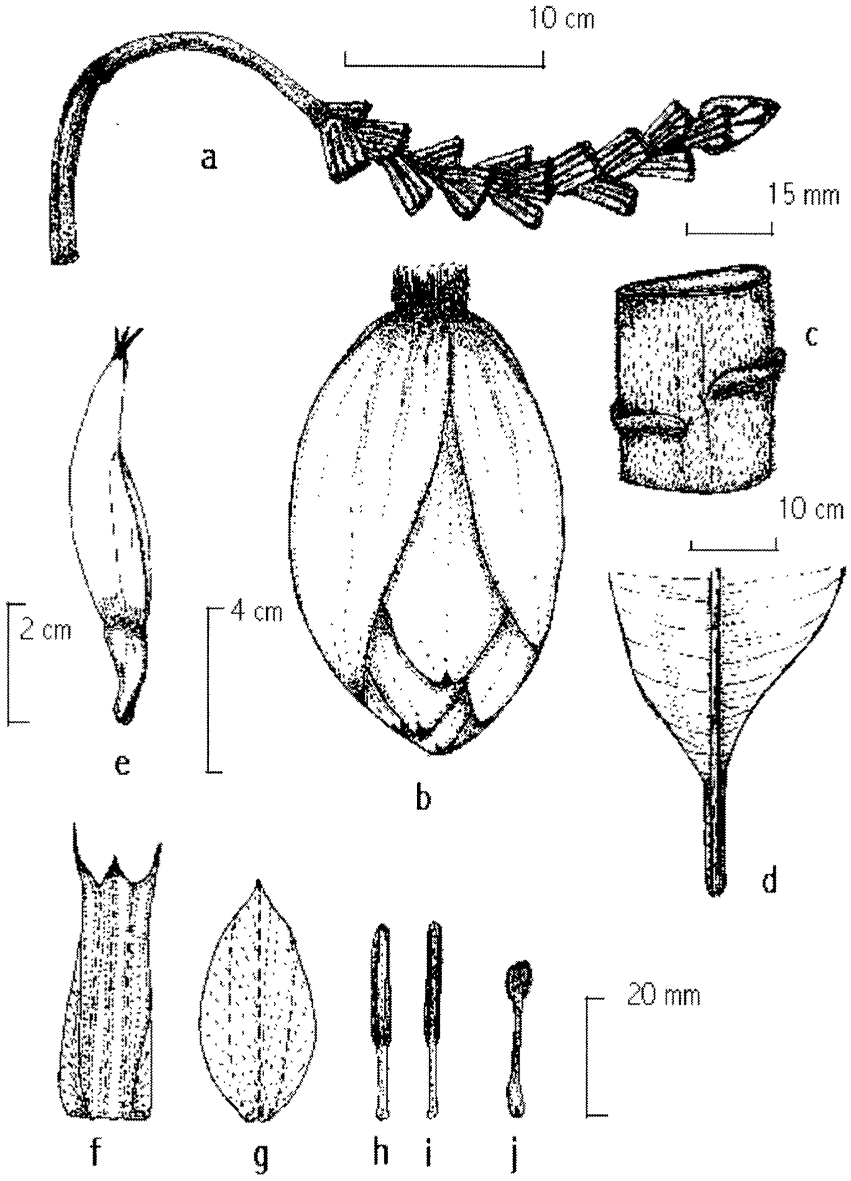

FIG. 7. *Musa borneensis* Becc. var. *lutea* Häkkinen & Meekiong, var. nov. a: Peduncle with unpollinated fruits and female bud. b: Female bud. c: Peduncle. d. Leaf base. e: Male flower. f: Compound tepal of male flower. g. Free tepal of male flower.h, i: Staminode with anther. j: Style with stigma.

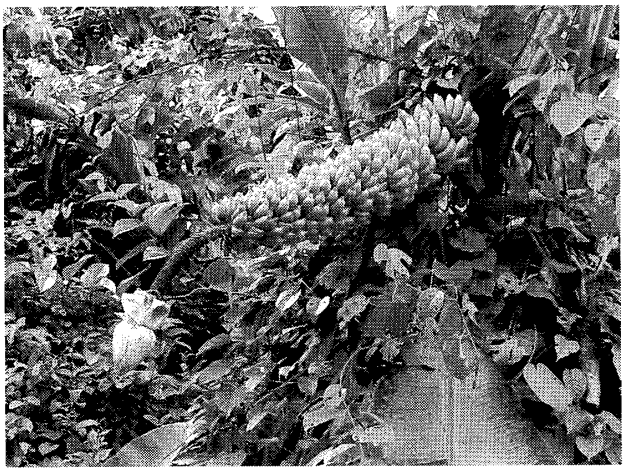

FIG. 8. *Musa borneensis* Becc. var. *lutea* Häkkinen & Meekiong, var. nov.

to 80 cm long, petiole canal wide open with erect margins, petiole bases winged and clasping the pseudostem with heavily corrugated auricles and extensive brown pigmentations. **Leaf** habit intermediate, lamina up to 400 cm long, 80 cm wide, oblong, slightly narrowed towards the apex, roundly truncate at the tip, colour of upper and lower surface medium green and shiny, leaf bases asymmetric and both sides pointed, midrib dorsally light green, ventrally yellow, with very corrugated lamina. Fig. 7d. **Inflorescence** first semi-horizontal then pendulous, peduncle 55 cm long, 7 cm in diameter, slightly hairy and purple to black in colour, sterile bract 1, with foliage lamina, deciduous at the opening of the first basal flowers. Fig. 7a & c. **Female flowers** on basal 36 nodes, each bearing 4-8 uniseriate flowers, ovary 4 cm long, light green, arrangements of ovules in two rows per loculus, compound tepal 7 cm long, with two prominent thickened keels hyaline margins, yellow at the base in colour, centre white and green the tip, free tepal, boat shaped, 6 cm long, apex developed with triangular shaped, translucent white, the style 4.5 cm long with globose cream stigma 10 mm. long, 6 mm in diameter. Fig. 7b. **Male bud** rounded or cordate, 17 cm long, 16 cm wide, bracts imbricate, apex obtuse with green tips, dorsally and ventrally dull yellow, with very little wax, lifting two or more bracts at a time and revolute before falling. **Male flowers** on average 5 per bract in one row, compound tepal 7 cm long, apex green and white to yellow in colour, ribbed at the dorsal angles, apex developed with 3 lobes, outer lobes acute with short dorsal appendages, the central lobe acute, free tepal 5.5 cm long, translucent white, lanceolate, acute, simple folding under apex, fertile stamens 5, filament 2.8 cm long, cream, anther 2.3 cm, white, style 2.4 cm, white, 4.5 cm, anthers and style inserted under the free tepal, stigma cream, abortive ovary straight 1.2 cm long, cream without pigmentation. Figs. 7e-j. **Fruit** bunch truncated cone shaped, compact, with 36 hands and 4-8 fruits per hand, first hand 8 fruits and the last hand 4 fruits, uniseriate, parallel to stalk, individual fruit 6-12 cm long, curved to straight in shape, without any floral relicts on the fruit apex, pedicel 2.3cm, partially fused, apical part blunt-tipped shaped with truncate apex, immature fruit peel light green, becoming yellow at maturity, pulp white becoming cream and soft at maturity. **Seeds** obpyriform, tuberculate, roughish in the upper half, 4-5 mm in diameter, 6-7 mm. in height, 100-120 seeds per fruit. Chromosome number 2n = 20.

Distribution: West Sabah around Crocker range and east Sabah around Tawau.

Vernacular name: Pisang wongkod.

Additional herbarium specimen examined: MALAYSIA. Sabah, Tawau, near Sungai, Mawang about 50 km NW of Tawau, road side open place, Nov. 9, 1968, *S. Kokawa & M. Hotta. 818* (KYO), Penampang, along the road between Babagon and Mts. Alab, alt. 500 m., Dec. 15, 1968, *S. Kokawa & M. Hotta 2301* (KYO), Tenom, along Sungai Pangi, alt. 150 m., Dec. 24, 1968, *S. Kokawa & M. Hotta 2659* (KYO).

Additional living material observed: MALAYSIA. Sabah, between Lahad Datu and Sandakan: 71 m alt., 04° 49.845 N, 118° 11.831 E, May 21, 2004, *M. Häkkinen et. al.*, 53 m. alt., 04° 28.641 N, 118° 09.503 E, May 21, 2004. *M. Häkkinen et. al.* Fig. 7k.

5. Musa borneensis Becc. var. **phoenicea** Häkkinen & Meekiong, **var. nov.,** Figs. 1, 3, 9a-j.

A *M. borneensi* Becc. var. typica surculis usque ad 2 tantum, succo rubropurpureo, inflorescentiae pedunculo brunneopurpureo glabro, cyaneibus maculis praedito, stigmate cyanopurpureo, infructescentia laxa cum tantum 7 manibus strictarum vel aliquando arcuatarum baccarum, seminibus paulo plus quam 40 in quaque bacca, pulpa flavescente solida dulcique praecipue differt.

Typus:MALAYSIA. Sarawak. Samarahan, Serian. Jalan Sungai Tahat, on road side, alt. 39 m, 01° 14.12' N, 110° 30.55' E, August 21, 2004. *K. Meekiong MK 1007* (holo SAR, iso HUMS).

Plant small slender, normally with one or two suckers, height of the parent, growth closely vertical with the parent. Mature pseudostem up to 3.5 m high, sheaths red to purple, underlying colour light-green with pink purple blotches, devoid of wax, sap watery red-purple. **Petiole** up to 75 cm long, petiole canal open with straight erect margins, petiole bases winged and clasping the pseudostem with corrugated auricles and sparse black-purple pigmentations. Fig. 9a. **Leaf** habit erect, lamina up to 360 cm long, 86 cm wide, oblong, slightly narrowed towards the apex, roundly truncate at the tip, colour of upper surface green and shiny, lower surface medium green and dull, leaf bases asymmetric and both sides rounded, midrib dorsally purple to blue, ventrally yellow, with very corrugated lamina. **Inflorescence** first horizontal then pendulous; peduncle hairless, 65 cm long, 5 cm diameter, purple brown with blue blotches, 2 empty nodes. Fig. 9b. **Female flowers** on basal 8 nodes, each bear 5-7 uniseriate flowers, arrangement ovules in two rows per loculus. **Male bud** rounded, 10 cm long, 10 cm wide, bracts overlap at the apex of the bud, apex obtuse with light green tips, dorsally pink-purple without discoloured stripes, ventrally yellow, with very little wax lifting two or more bracts at a time and not revolute before falling. Fig. 9c. **Male flowers** on average 6 per bract in one row, compound tepal 4.7 cm long, the upper part light green in colour, and cream to yellow at the base, ribbed at the dorsal angles, apex developed with two lobes, free tepal 4.4 cm long, opaque white, oval shape with triangular apex, simple folding under apex, fertile stamens 5, filaments 1.8 cm long, cream, anther 2.2 cm, rusty brown, style 2.8 cm, straight shape with purple pigmentation, anthers and style inserted, stigma purple blue, ovary arched, 15 mm long, cream without pigmentation. Figs. 5d-j. **Fruit** bunch lax, with 7 hands and 5-7 fruits per hand, the first hand 7 fruits and the last hand 5 fruits, uniseriate, parallel to stalk, individual fruit 12 cm long, straight in shape and some of them are curved with bottle-necked and without any floral relicts on the fruit apex, pedicel 2.4 cm long, smooth and totally fused, immature fruit light green, becoming yellow at maturity, pulp white becoming yellow firm and sweet at maturity. Seeds obpyriform, tuberculate, roughish in the upper half, 4-5 mm in diameter, 6-7 mm. in height, 40-50 seeds per fruit. Chromosome number 2n = 20.

Distribution: Bau, Kuching, Samarahan and Serian.

Vernacular names: Borak kodan (Bidayuh, Bau).

Additional herbarium specimens examined: MALAYSIA. Sarawak, Bukit Begunau: 63 m alt., 01° 06.136 N, 111° 23.067 E, September 25, 2002, *M. Häkkinen 8029* (SBC), 41 m alt., 01° 04.553 N, 111° 07.847 E, September 26, 2002, *M. Häkkinen 8030* (SBC).

6. Musa borneensis Becc. var. **sarawakensis** Häkkinen & Meekiong, **var. nov.,** Figs. 2, 3, 10a-j. A *M. borneensi* Becc. var. typica principali trunco pauce altiore, surculis usque ad 7, succo rubropurpureo, inflorescentiae pecunculo glabro, stigmate roseopurpureo, infrutescentia truncato-conica laxa cum baccis strictis, seminibus paulo plus quam 80 in quaque bacca, pulpa dulci praecipue differt.

Typus:MALAYSIA. Sarawak. Serian – Sri Aman, on road side, alt. 28 m, 01° 28.03' N, 110° 26.38' E, August 19, 2004. *K. Meekiong MK1005* (holo SAR, iso HUMS).

Plant tall robust, suckering freely, far from parent plant, up to 7 suckers, and of the height of the parent, position vertical, leaves of water sucker without blotches. Mature pseudostem up to 4.5 m high, sheaths purple-brown, underlying colour yellow, devoid of wax, sap red-purple. **Petiole** up to 60 cm long, petiole canal wide erect margins, winged and clasping the pseudostem, with corrugated auricles; petiole bases winged and clasping the pseudostem with heavily corrugated auricles and sparse black-purple blotching. Fig. 10a. **Leaf** habit erect, lamina up to 350 cm long, 80 cm wide, colour of upper surface green and shiny, lower surface medium green and dull, leaf bases asymmetric and both sides rounded, midrib dorsally light green to yellow, ventrally yellow, with very corrugated lamina. Fig. 10b. **Inflorescence** first horizontal then pendulous, peduncle 35 cm long, 6.5 cm diameter, hairless and light green-yellow in colour, sterile bract 1, with foliage lamina, deciduous at the opening of the first basal flowers. **Female flowers** on basal 12-26 nodes, each bearing 5-9 uniseriate flowers, arrangements of ovules in two rows per loculus. **Male bud** rounded or cordate, 17 cm long, 11 cm wide, young bracts

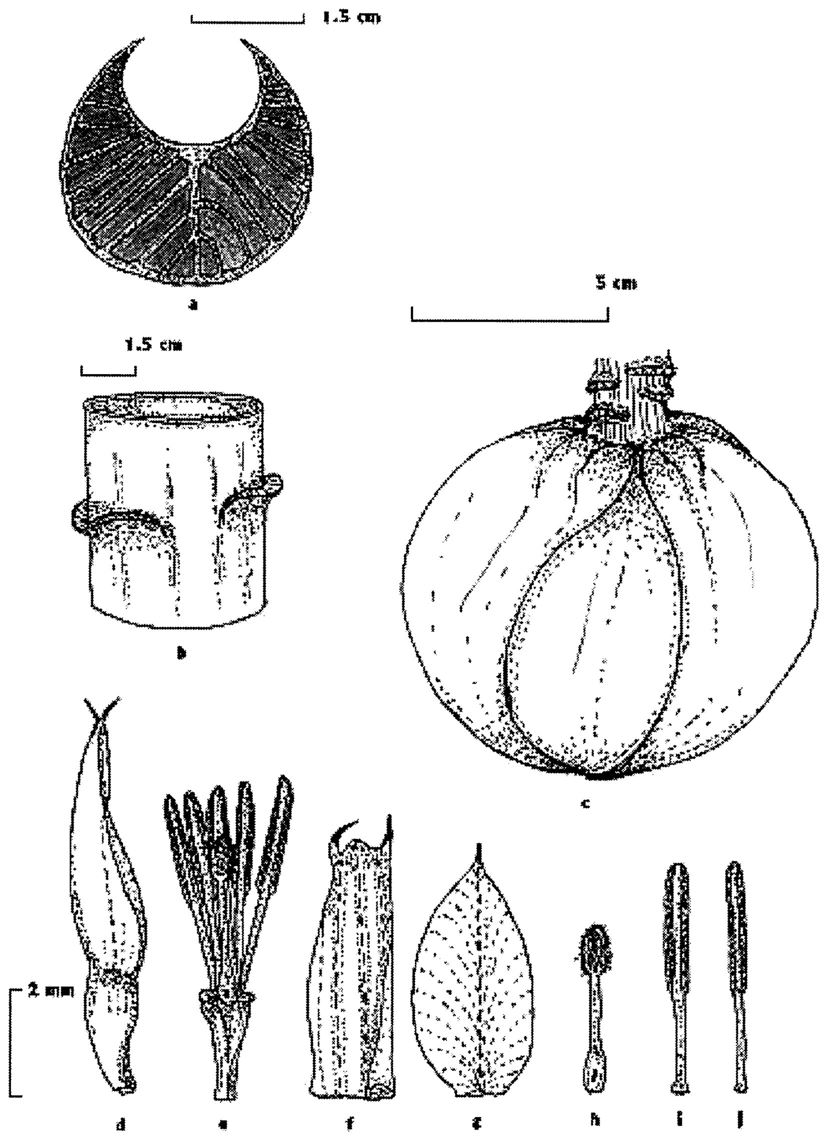

FIG. 9. *Musa borneensis* Becc. var. *phoenicea* Häkkinen & Meekiong, var. nov. a: Cross-section of petiole. b: Peduncle. c: Male bud. d, e: Male flower. f: Compound tepal of male flower. g: Free tepal of male flower. h: Style with stigma. i, j: Staminode with anther.

slightly overlap, apex obtuse and split with green tips, dorsally bract pink-purple with discoloured stripes, ventrally yellow, no visible sign of wax, lifting two or more at a time and revolute before falling, deciduous. Fig. 10c. **Male flowers** on average 5 per bract in one row, compound tepal 5.5 cm long, cream to yellow, with 5-toothed green developed apex, free tepal 4.6 cm long, cream, oval shape with triangular apex, simple folding under apex, style 2.5 cm long, white, stamens longer than style rusty brown, inserted under the free tepal, stigma pink-purple, ovary straight 1.5 cm long, cream to green in colour, without pigmentation. Figs. 10d-j. **Fruit** bunch truncated cone shaped, lax, with 12-26 hands and 5-9 fruits per hand on average, uniseriate, the fingers parallel to stalk, individual fruit 9 cm long, straight in shape, without any floral relicts on the fruit apex, pedicel 15 mm, totally fused, apical part blunt-tipped shaped with truncate apex, immature fruit peel light green,

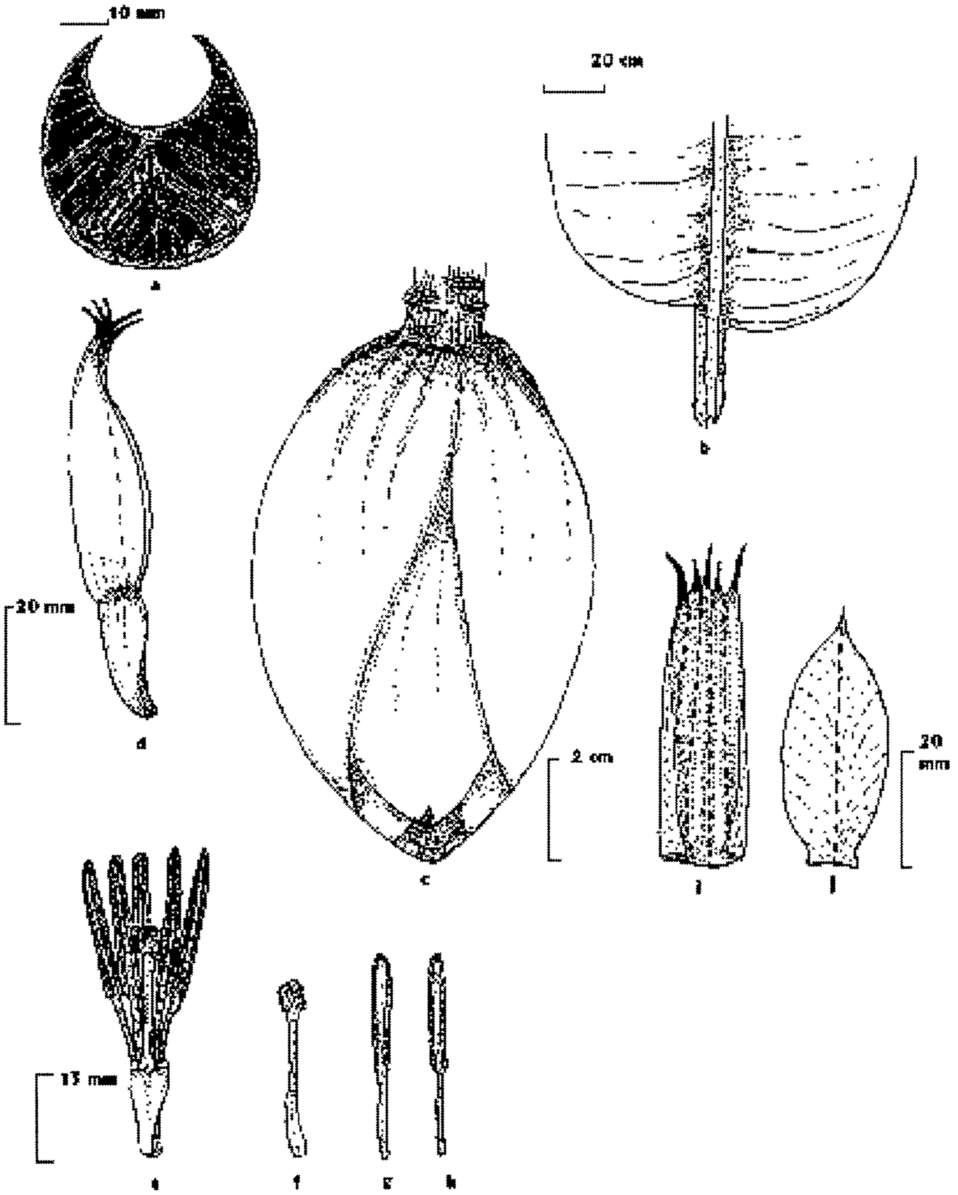

FIG. 10. *Musa borneensis* Becc. var. *sarawakensis* Hakkinen & Meekiong, var. nov. a: Cross-section of petiole. b: Leaf base. c: Male bud. d, e: Male flower. f: Style with stigma. g, h: Staminode with anther. i: Compound tepal of male flower. j: Free tepal of male flower.

becoming yellow at maturity, pulp white becoming cream and soft at maturity; taste sweet. **Seeds** obpyriform, tuberculate, roughish in the upper half, 4-5 mm in diameter, 6-7 mm. in height, 80-90 seeds per fruit. Chromosome number 2n = 20.

Distribution: Belaga, Bintulu, Padawan, Serian, Sri Aman.

Vernacular names: Pisang hutan (Malay), Baliek guun (Melanau).

Additional herbarium specimen examined: MALAYSIA. Sarawak, Batang Ai, 78 m alt., 01° 06.218 N, 111° 13.356 E, September 23, 2002, *M. Häkkinen 8026* (SBC), 123 m alt., 01° 16.078 N, 111° 56.067 E, September 24, 2002, *M. Häkkinen: 8027* (SBC).

Additional living material observed: MALAYSIA. Sarawak, near Belaga, 141 m alt., 02° 41.920 N, longitude 113° 45.600 E, May 7, 2004, *M. Häkkinen et. al.*, 507 m alt., 02° 45.027 N, 113° 45.027 E, May 7, 2004, *M. Häkkinen et. al.*, 165 m alt., 02° 45.775 N, 113° 46.058 E., May 7, 2004, *M. Häkkinen et. al.*

Conclusion

It has become very clear during this study that *Musa borneensis* is spread almost all over Borneo and has evolved into several different varieties depending on the growing conditions and areas. Its absence, however, is noticeable in some parts in northern Borneo. The first author has seen several other varieties of *M. borneensis* in West and East Kalimantan of which one had hermaphrodite female flowers. As well, the author has seen at Tenom Agricultural Park, Sabah one unidentified *M. borneensis* variety under cultivation, whose origin was unknown. All these merit further research.

In earlier literature it is mentioned that *Musa textilis* Nee, which was an introduction for fibre production in the early 20th century in Borneo from the Philippines, hybridised easily with *M. borneensis* due to the fact that they both have the same number of chromosomes, but the authors have seen only a few hybrids during their field work in the past years (Shepherd 1999, Häkkinen & Meekiong 2004). However *M. textilis* was widely dispersed from the original planting sites and plant material, which escaped to nature after the plantations were abandoned, and it is now found almost all over the islands with the number of variations in double digits (Bishop & Curtler 1925, Marsh 1947).

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APPENDIX The main differentiating characteristics of *Musa borneensis* varieties.

Descriptor	var. *borneensis*	var. *flavida*	var. *alutacea*
Figures	4 A - E.	5 A - E.	6 a -q.
Plant height	3.5 meter or less	3.5 meter or more	3.5 meter or more
Pseudostem colour	Purple-brown	Medium green	Light green
Pseudostem apppearance	Shiny (not waxy) slender	Dull (waxy) robust	Shiny (not waxy) robust
Underlying colour of the pseudostem	Cream	Yellow	Light green
Pigmentation of the underlying pseudostem	Purple blotches	Sparse purple blotches	Pink-purple blotches
Sap colour	Milky	Milky	Red-purple
Wax on the pseudostem	Shiny	Waxy	Shiny
Blotches at the petiole base	Sparse red-purple blotches blotches	Sparse blue blotches	Extensive black-purple
Petiole canal leaf 3.	Open with erect margins	Wide with erect margins	Straight with erect margins
Petiole margin base	Winged and not clasping the pseudostem	Winged and not clasping the pseudostem	Winged and clasping the pseudostem
Colour of leaf upper surface	Green	Medium green	Green
Appearance of leaf upper surface	Shiny	Dull	Shiny
Colour of leaf lower surface	Medium green	Light green	Light green
Appearance of leaf lower surface	Shiny	Dull	Dull
Insertion point of leaf blades on petiole	Symmetric	Asymmetric	Asymmetric
Shape of leaf blade base	One sides rounded one pointed	Both sides pointed	Both sides pointed
Colour of midrib dorsal surface	Light green	Light green	Light green
Colour of midrib ventral surface	Yellow	Yellow	Yellow
Peduncle colour	Green-yellow	Medium green	Light green to yellow
Peduncle hairiness	Slightly hairy	Hairless	Hairy
Male bud shape	Ovoid	Ovoid	Intermediate (rounded to ovoid)
Colour of the bract external face	Red-purple	Yellow	Leathery yellow
Colour of the bract internal face	Yellow to purple	Pale yellow	Yellow
Colour on the bract apex	With green tips	With green tips	With green tips
Male bract lifting	Lifting two or more at a time, not revolute before falling	Lifting two or more at a time, revolute before falling	Deciduous, not revolute before falling
Wax on the bract	Moderately waxy	Very little or no visible sign of wax	Very little or no visible sign of wax
Male flower behaviour	Falling with the bract	Falling after the bract	Falling before the bract
Compound tepal basic colour	Cream to yellow	Green to pale yellow	Light green to cream-orange
Free tepal shape	Oblong	Lanceolate	Oval
Anther exsertion	Exserted	Exserted	Same level
Stigma colour	Tinted with purple	Tinted with purple	Cream
Ovary shape	Arched	Arched	Arched
Ovary basic colour	Pale yellow	Pale yellow	Cream
Number of fruits	20 hands, 5-8 fruits per hand	26 hands, 5-6 fruits per hand	8 hands, 6-8 fruits per hand
Fruit shape (longitudinal)	Slightly curved	Curved (sharp curve)	Straight in shape
Tranverse section of the fruit	Pronounced ridged	Slightly ridged	Pronounced ridged
Fusion of pedicels	Totally fused	Partially fused	Partially fused
Pulp colour at maturity	Cream	Cream	Yellow
Number of seeds per fruit	120-130	80-90	80-100

APPENDIX (continued)

Descriptor	var. *lutea*	var. *phoenicea*	var. *sarawakensis*
Figures	7 a – j & 8.	1, 9 a - j.	2, 10 a - j.
Plant height	3.5 meter or more	3.5 meter or less	3.5 meter or more
Pseudostem colour	Medium green	Red-purple	Purple-brown
Pseudostem apppearance	Shiny (not waxy) robust	Shiny (not waxy) slender	Shiny (not waxy) robust
Underlying colour of the pseudostem	Yellow	Light green	Yellow
Pigmentation of the underlying pseudostem	Red-purple blotches	Pink-purple blotches	Without blotches
Sap colour	Light yellow	Watery red-purple	Red-purple
Wax on the pseudostem	Shiny	Shiny	Shiny
Blotches at the petiole base	Extensive brown blotches	Sparse black-purple blotches	Sparse black-purple blotches
Petiole canal leaf 3.	Open with erect margins	Straight with erect margins	Wide with erect margins
Petiole margin base	Winged and clasping t he pseudostem	Winged and clasping he pseudostem	Winged and not clasping he pseudostem
Colour of leaf upper surface	Medium green	Green	Green
Appearance of leaf upper surface	Shiny	Shiny	Shiny
Colour of leaf lower surface	Medium green	Medium green	Medium green
Appearance of leaf lower surface	Shiny	Dull	Dull
Insertion point of leaf blades on petiole	Asymmetric	Asymmetric	Asymmetric
Shape of leaf blade base	Both sides pointed	Both sides rounded	Both sides rounded
Colour of midrib dorsal surface	Light green	Purple to blue	Light green to yellow
Colour of midrib ventral surface	Yellow	Yellow	Yellow
Peduncle colour	Purple to black	Purple-brown	Light green to yellow
Peduncle hairiness	Slightly hairy	Hairless	Hairless
Male bud shape	Rounded or cordate	Rounded	Rounded or cordate
Colour of the bract external face	Dull yellow	Pink-purple	Pink-purple
Colour of the bract internal face	Dull yellow	Yellow	Yellow
Colour on the bract apex	With green tips	Pink-purple	With green tips
Male bract lifting	Lifting two or more at a time, revolute before falling	Lifting two or more at a time, not revolute before falling	Lifting two or more at a time
Wax on the bract	Very little of wax	Very little of wax	Very little or no visible sign of wax
Male flower behaviour	Falling with the bract	Falling after the bract	Falling after the bract
Compound tepal basic colour	Green to white-yellow	Light green to cream yellow	Cream to yellow
Free tepal shape	Lanceolate	Oval	Oval
Anther exertion	Inserted	Inserted	Inserted
Stigma colour	Cream	Purple-blue	Pink-purple
Ovary shape	Straight	Arched	Straight
Ovary basic colour	Cream	Cream	Cream to green
Number of fruits	36 hands, 4-8 fruits per hand	7 hands, 5-7 fruits per hand	12-26 hands, 5-9 fruits per hand
Fruit shape (longitudinal)	Slightly curved	Slightly curved	Straight in shape
Tranverse section of the fruit	Slightly ridged	Pronounced ridged	Pronounced ridged
Fusion of pedicels	Partially fused	Totally fused	Totally fused
Pulp colour at maturity	White	Yellow	Cream
Number of seeds per fruit	100-120	40-50	80-90